On the Upward Temperature Trend (1983-2010) in the NMME Hindcasts

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Some Preliminary Thoughts and Questions

➢ **Little known secret: The skill of seasonal T2m prediction during 1982-present period depends very strongly on the upward T2m trend. (more so than on ENSO, or soil moisture……).**

➢ **Seasonal prediction and climate change are thus mixed up. This makes NMME, unexpectedly, a climate change investigative tool. Do models have the upward trend (correct)? Each center decided on its model version, no carefully designed/coordinated experiment.**

➢ **CFSv1 had no CO_2 increase, but still had an upward (albeit too weak) SST/T2m trend (in lead X predictions, X=1 month to X=9 months) over the ocean because of ocean data assimilation.**

➢ **In addition to ocean data assimilation, do we need an increase in CO_2 to get the SST forecast right?**

➢ **Is a correct SST prediction enough to produce an upward T2m trend over land? Or do we need increases in CO_2 in the seasonal forecast model?**

NMME Forecast Providers Year 1

Model	Hindcast Period	Ensemble Size	Lead Times	Arrangement of Ensemble Members	Contact and reference
CFSv1	1981-2009	15	0-8 Months	1st 0Z +/-2 days, 21^{st}0Z +/-2d, 11th 0Z+/- 2d	Saha (Saha et al. 2006)
CFSv2	1982-2009	24(28)	0-9 Months	4 members (0,6,12,18Z) every 5th day	Saha (Saha et al. 2010)
GFDL-CM2.2	1982-2010	10	0-11 Months	All 1st of the month 0Z	Rosati (Zhang et al. 2007)
IRI-ECHAM4-f	1982-2010	12	0-7 Months	All 1st of the month 0Z	DeWitt (DeWitt 2005)
IRI-ECHAM4-a	1982-2010	12	0-7 Months	All 1st of the Month 0Z	DeWitt (Dewitt 2005)
CCSM3.0	1982-2010	6	0-11 Months	All 1st of the Month 0Z	Kirtman (Kirtman and Min 2009)
GEOS5	1981-2010	6	0-9 Months	1 Member every 5th day	Schubert (Vernieres et al. 2011)

NMME Forecast providers YEAR 2 & 3

| Model name	Period	Members	Arrangement of Members	Lead (months)	Model resident Resolution: Atmosphere	Model resident Resolution: Ocean	Reference
NCEP-CFSv2	1982-2010	24(28)	4 members (0,6,12,18Z) every 5th day	0-9	T126L64	MOM4 L40 0.25 deg Eq	Saha et al. (2010)
GFDL-CM2.1	1982-2010	10	All 1st of the month 0Z	0-11	2x2.5deg L24	MOM4 L50 0.30 deg Eq	Delworth et al. (2006)
CMC1-CanCM3	1981-2010	10	All 1st of the month 0Z	0-11	CanAM3 T63L31	CanOM4 L40 0.94 deg Eq	Merryfield et al. (2012)
CMC2-CanCM4	1981-2010	10	All 1st of the month 0Z	0-11	CanAM4 T63L35	CanOM4 L40 0.94 deg Eq	Merryfield et al. (2012)
NCAR-CCSM3.0	1982-2010	6	All 1st of the month**	0-11	T85L26	POP L40 0.3 deg Eq	Kirtman and Min (2009)
NASA	1981-2010	6	1 member every 5th day as CFSv2	0-9	1x1.25deg L72	MOM4 L40 1/4 deg at Eq	Rienecker et al. (2008)

SST Trend for 1983-2010 Averaged for Global Ocean

1983—2010 Global Ocean Average SST
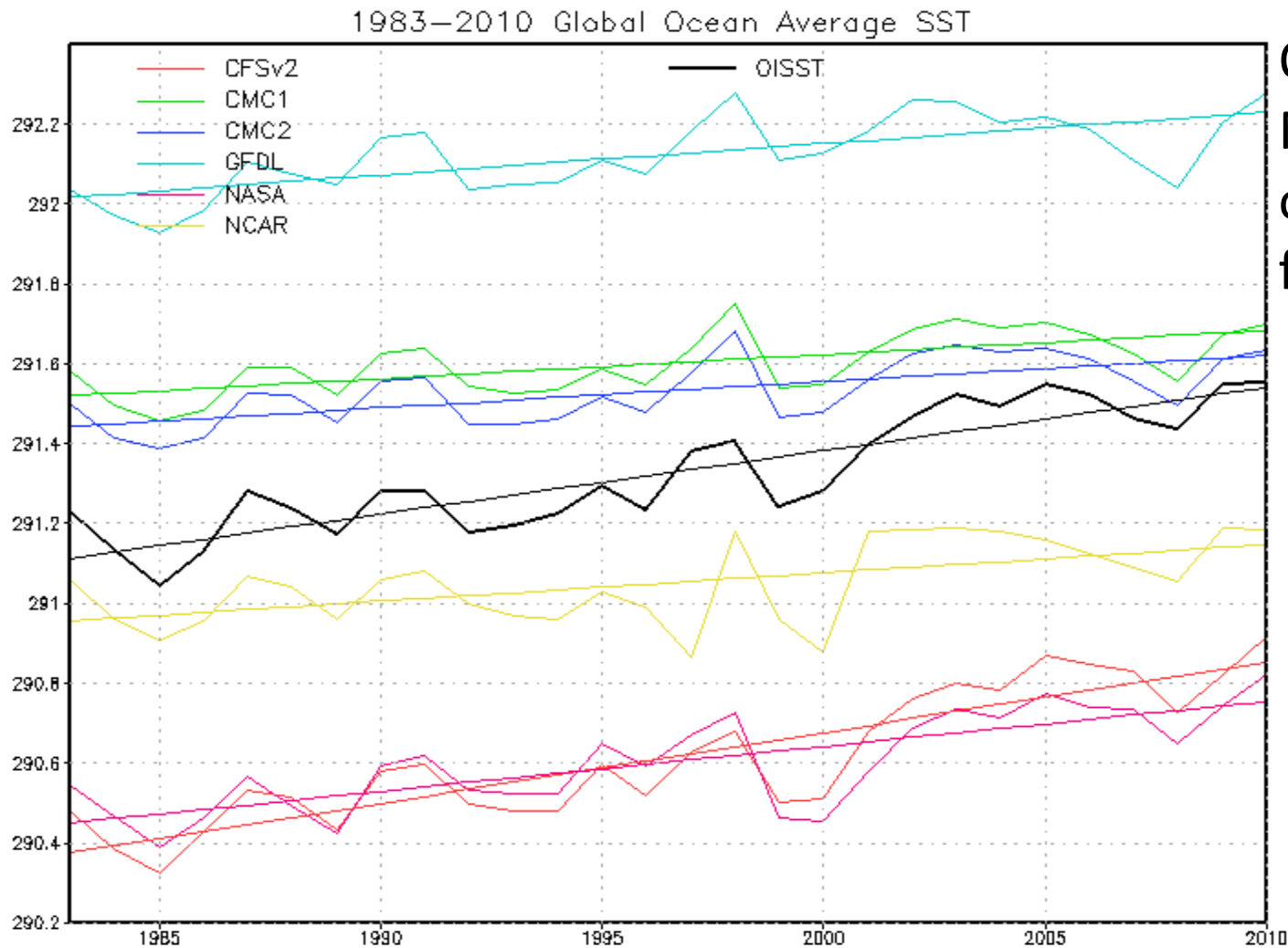
OISST and 6 NMME Models of lead 1 month forecast

T2m Trend for 1983-2010 Averaged for Global Land

1983–2010 Global Land Average T2m
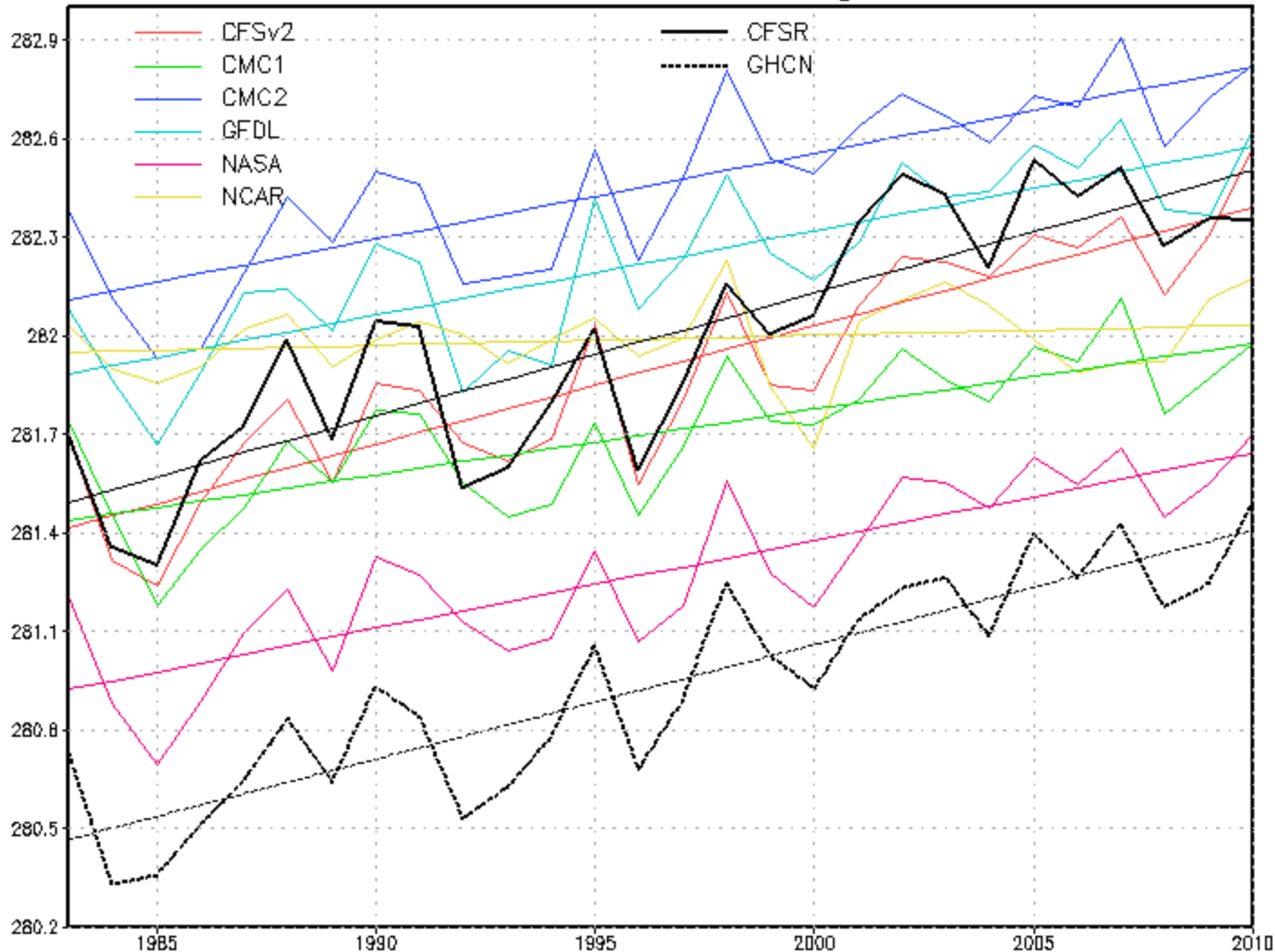
CFSR, GHCN and 6 NMME Models of lead 1 month forecast

Please note

- SST vs T2m issues over the ocean and land
- Some models have been used for IPCC before.
- Not only CO2. GFDL is run under "scenario" 2004, which prescribes aerosol .
- The choice of the period is 1983-2010 for lead1-8 month forecast.
- Mainly annual mean temperature for model ensemble mean

Compare 30 Years Linear Trend of Global Mean

	CFSR	OISST/ GHCN-CAMS	CFSv2	CMC1	CMC2	GFDL	NASA	NCAR
Ocean	0.46	0.48	0.53	0.18	0.20	0.24	0.34	0.21
Land	1.12	1.05	1.08	0.60	0.79	0.77	0.80	0.09

➢ Two observational estimates are shown:
CFSR and OISST agree to within 0.01 that the (global mean) upward trend over the ocean is +0.47.
CFSR and GHCN/CAMS agree to within 0.035 that the (global mean) upward trend over the land is +1.075.

➢ The 6 model estimates are based on a time series of lead 1-month forecasts, still close to the initial condition. Of the six models CFSv2 has about the right upward T2m trend (global mean). Substantial improvement over CFSv1.

➢ All other models do have an upward trend, but weak, both over land and ocean.
Given that all models strive for a credible ocean data assimilation, it is ***surprising*** that so many models have such a weak upward trend in one-month-lead forecast SST over the ocean.

➢ The upward trend over land is too weak in 5 out of 6 models, by a few tenths (out of a 1.1 total). Perhaps this is caused by the trends over the ocean being too weak. Curiously the NCAR has virtually no upward trend over land.

➢ The NCAR model has its GHG increase turned off for the NMME application. Apparently a temperature increase in the ocean alone is not enough to make it warmer over land.

Compare 30 Years Linear Trend for Leading Month

	CFSR	OISST GHCN-CAMS	CFSv2	CMC1	CMC2	GFDL	NASA	NCAR
Ocean	0.46	0.48	0.53	0.18	0.20	0.24	0.34	0.21
Land	1.12	1.05	1.08	0.60	0.79	0.77	0.80	0.09

LEAD 1

	CFSR	OISST GHCN-CAMS	CFSv2	CMC1	CMC2	GFDL	NASA	NCAR
Ocean	0.46	0.48	0.49	0.09	0.22	0.44	0.21	0.26
Land	1.12	1.05	0.87	0.30	0.62	1.14	0.77	0.08

LEAD 8

We now compare results for lead 1 (close to initial time) and lead 8 (deeper into the model's climate).

➢ **Most models have equal or weaker trends at lead 8 compared to lead 1. The only clear exception is GFDL. GFDL manages to increase trends, in fact to realistic values, deeper into the forecast, over both land and ocean.**

➢ **CFSv2 is weaker at lead 8 than at lead 1, but still reasonably good and a big improvement over CFSv1.**

Compare 30 Years Linear Trend for CFSv1 & 2

	CFSR	OISST GHCN-CAMS	CFSv1	CFSv2
Ocean	0.46	0.48	0.21	0.53
Land	1.12	1.05	0.63	1.08

LEAD 1

|	CFSR	OISST GHCN-CAMS	CFSv1	CFSv2
Ocean	0.46	0.48	0.08	0.49
Land	1.12	1.05	0.26	0.87

LEAD 8

➢ **Cai et al 2009 concluded that CFSv1 (fixed CO2 at 1988 value) had a weak T2m and SST increase because climate change was forced in only thru the initialized ocean.**

➢ **The upward trend was already weak in the early leads, and eroded to 40% of its initial value at lead 8 months.**

➢ **CFSv2 fixed most of this problem, and CO2 increases help explain what is observed.**

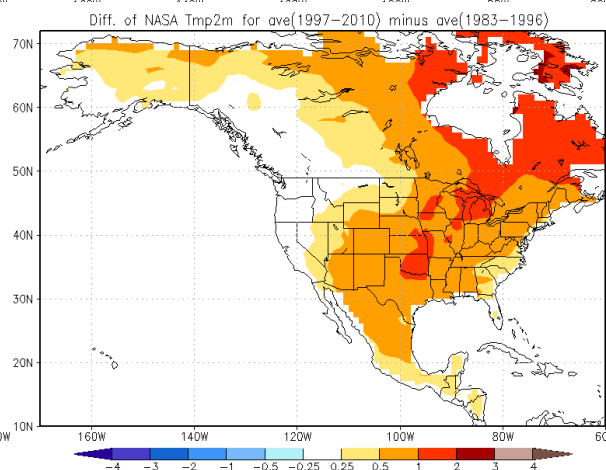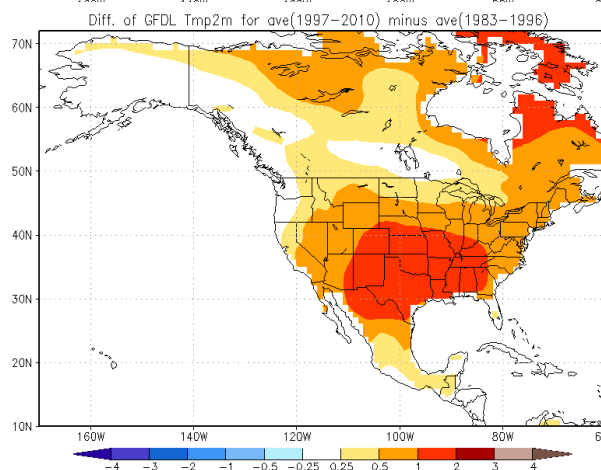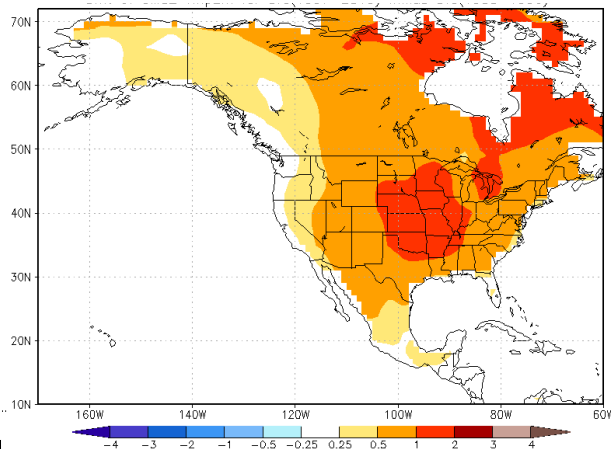# Difference of SST for period average (1997-2010) minus (1983-1996)

Diff. of OISST for ave(1997-2010) minus ave(1983-1996)

Diff. of CFSv2 SST for ave(1997-2010) minus ave(1983-1996)

Diff. of CMC1 SST for ave(1997-2010) minus ave(1983-1996)

Diff. of CMC2 SST for ave(1997-2010) minus ave(1983-1996)

Diff. of GFDL SST for ave(1997-2010) minus ave(1983-1996)
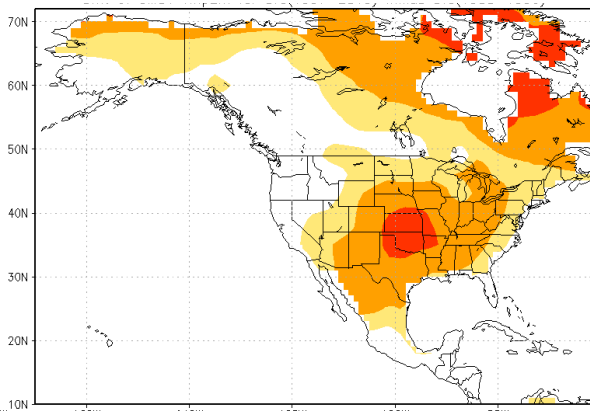
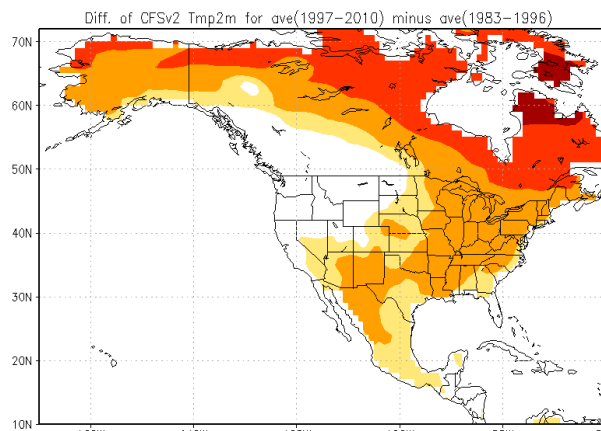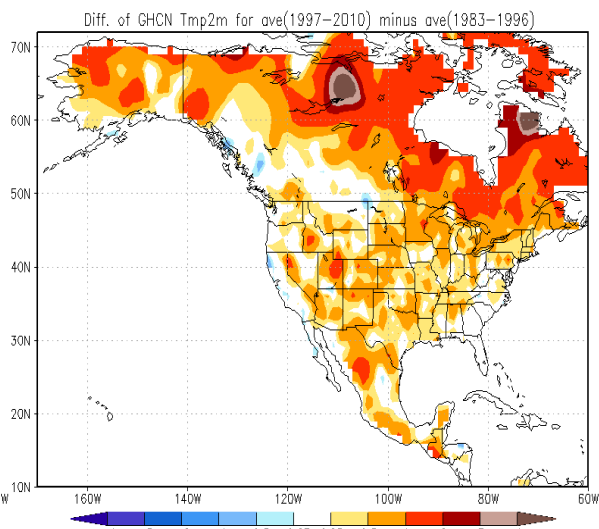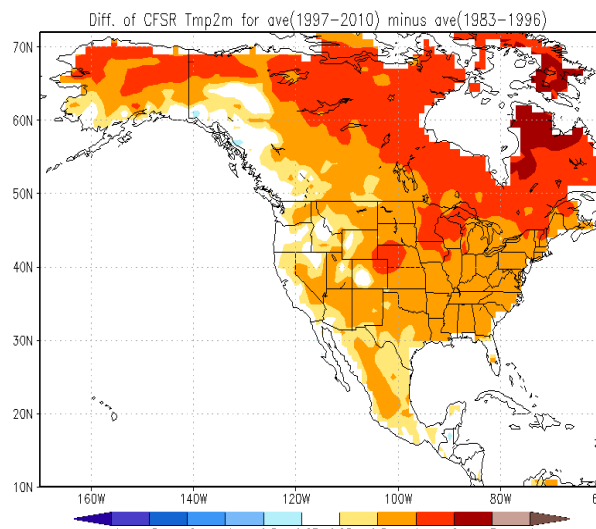Diff. of NASA SST for ave(1997-2010) minus ave(1983-1996)
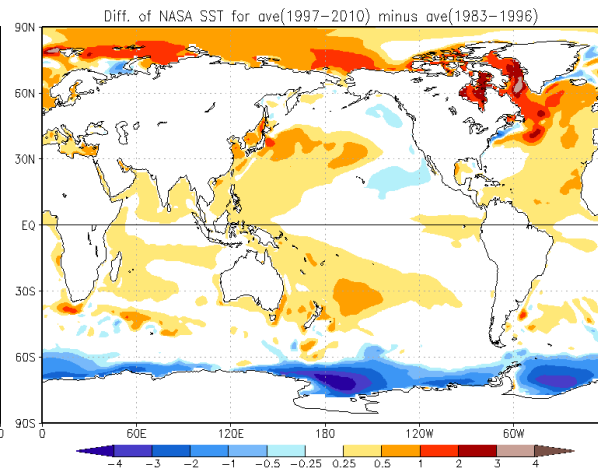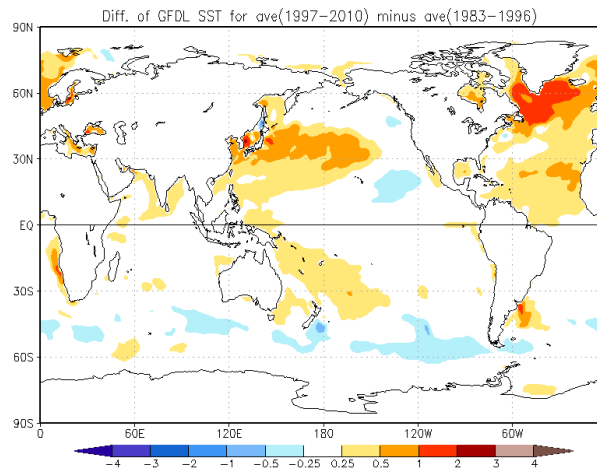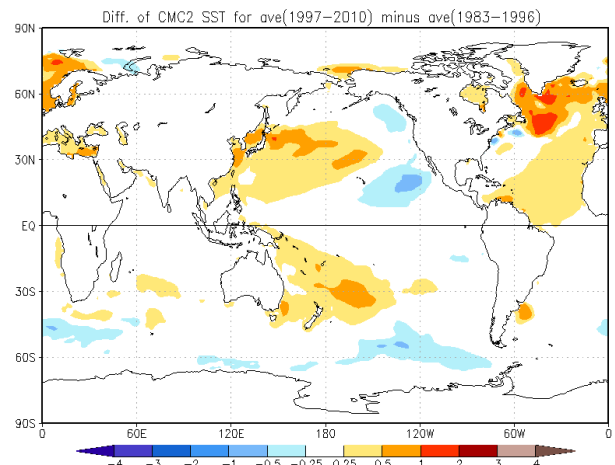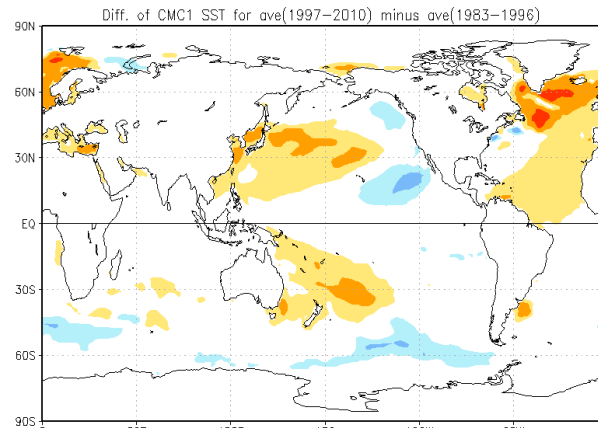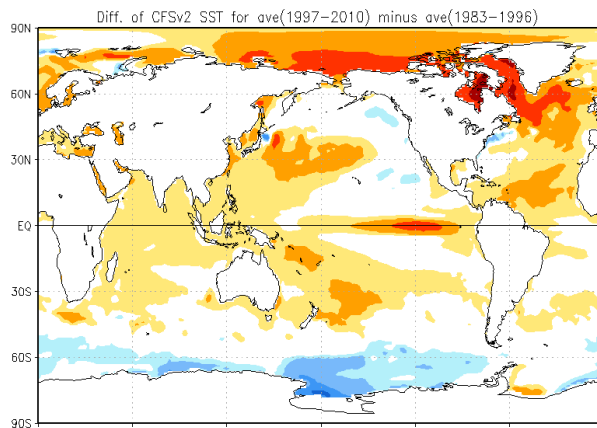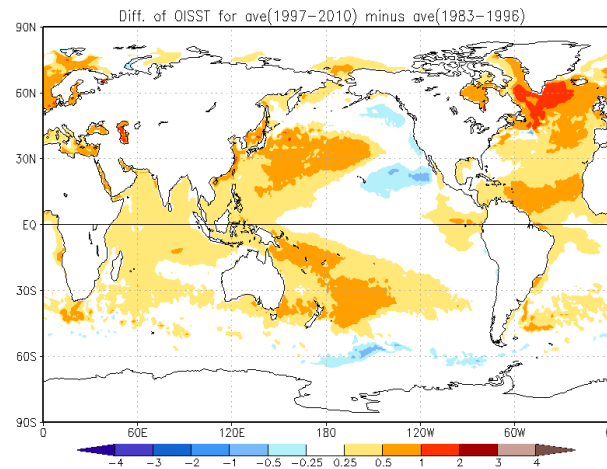
Lead 1 month SST forecast

Difference of T2m for period average (1997-2010) minus (1983-1996)
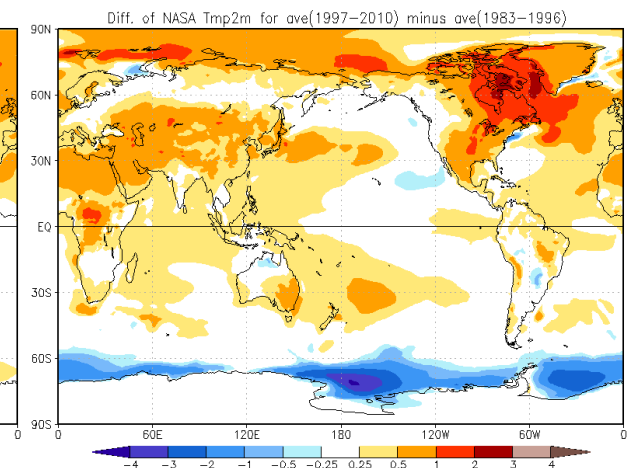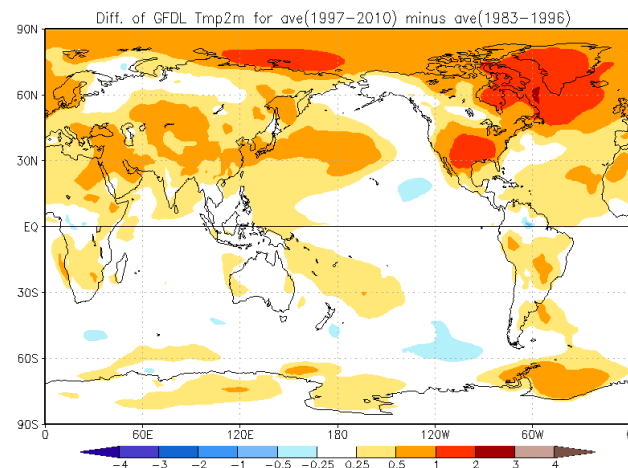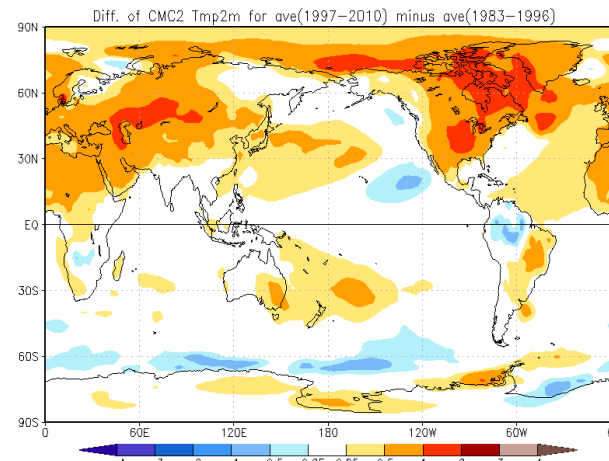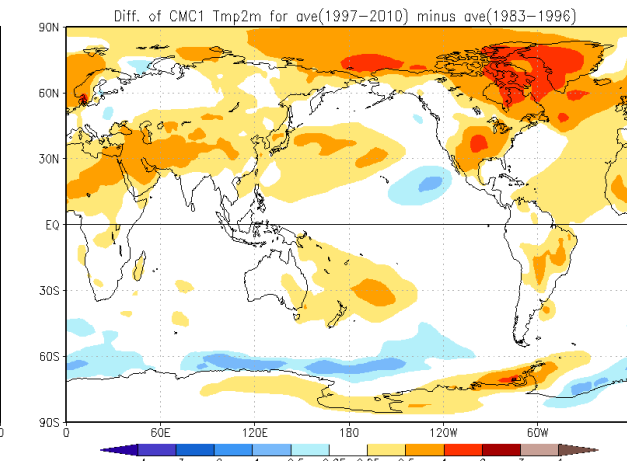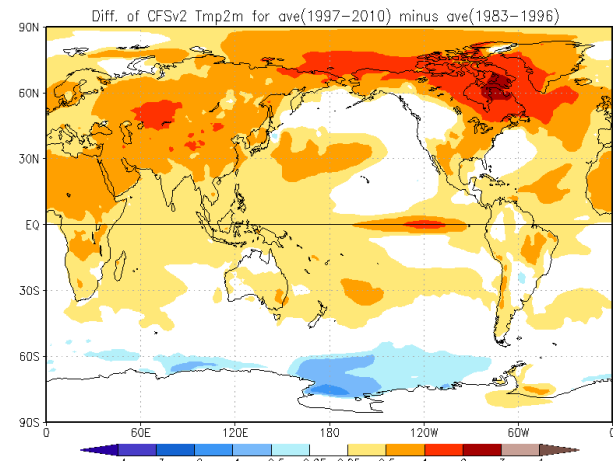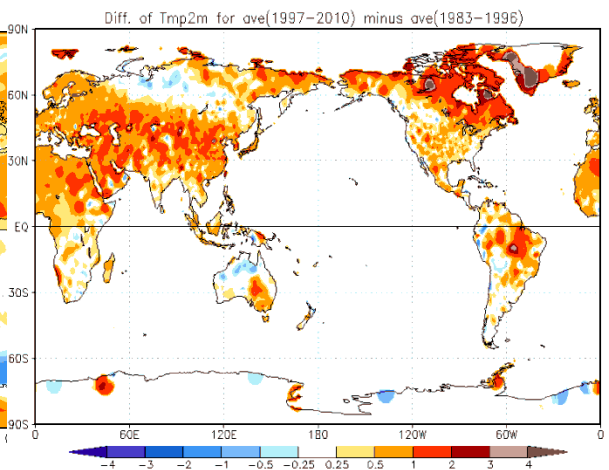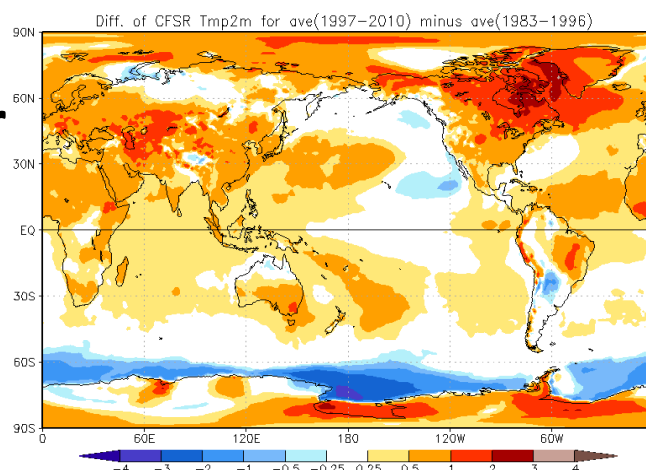
Lead 1 month
T2m forecast

Difference of T2m for period average (1997-2010) minus (1983-1996)

Diff. of CFSR Tmp2m for ave(1997-2010) minus ave(1983-1996)

Diff. of GHCN Tmp2m for ave(1997-2010) minus ave(1983-1996)

Diff. of CFSv2 Tmp2m for ave(1997-2010) minus ave(1983-1996)

Diff. of GFDL Tmp2m for ave(1997-2010) minus ave(1983-1996)

Diff. of NASA Tmp2m for ave(1997-2010) minus ave(1983-1996)

Lead 1 month
T2m forecast

Remarks and Discussion

1. Most models have weaker upward trend than observed, both over land and over ocean.

2. In spite of credible ocean data assimilation models produce upward trends that may differ by a factor of 2 to the lead 1 month SST forecast.

3. One model, that turned off the CO2 increase, has temperature increase over the ocean, but not over land.

4. Spatial patterns of the trend in T2m and SST are somewhat similar across models, but with plenty of regional exceptions.